Universitat Oberta de Catalunya

artnodes
E-JOURNAL ON ART, SCIENCE AND TECHNOLOGY

https://artnodes.uoc.edu

ARTICLE

NODE "MATERIOLOGY AND VARIANTOLOGY: INVITATION TO DIALOGUE"

In the beginning, there was the analogue. An alternative history of the beginnings of computer art

Margit Rosen
ZKM | Center for Art and Media Karlsruhe

Date of submission: April 2024
Accepted in: May 2024
Published in: July 2024

Recommended citation

Rosen, Margit. 2024. «In the beginning, there was the analogue. An alternative history of the beginnings of computer art». In: Siegfried Zielinski and Daniel Irrgang (coords.). Node «Materiology and Variantology: invitation to dialogue». *Artnodes*, no. 34. UOC. [Accessed: dd/mm/yy]. https://doi.org/10.7238/artnodes.v0i34.424662

Abstract

Since the late 1960s, the historiography of computer art has been developing a canon that is progressively broadening. However, this canon reveals significant blind spots, particularly due to the predominant success of digital computers leading to computer art being almost exclusively identified with digital technology. This identification overlooks other significant classes of computers, notably analogue and hybrid systems, leaving the contributions, artworks, and ideas of many early pioneers in the field unrecognized. Consequently, the history of art created with analogue and hybrid computers remains largely unexplored both in art history and media archaeology.

This article seeks to illuminate this relatively obscure chapter of history by introducing the individuals and projects that utilized analogue computers, drawing on previously unknown historical sources. The aim is to underscore the historical significance of a technology that is currently experiencing a resurgence of interest in the field of computer science.

The findings reveal that before the advent of artistic experiments with digital computers, analogue computers were the subject of pioneering exploration. The real-time intuitive operation of analogue computers was a unique advantage, foreshadowing a human-machine relationship now commonplace with digital technology.

The narrative of the analogue computer constitutes an essential domain for understanding the diversity of computing technologies at the dawn of the computer age. Despite the scarcity of sources documenting these artistic endeavors, this article serves as a call to action for further research in this neglected area.

Keywords

computer art; analogue computer; hybrid computer; oscilloscope; plotter; human-machine interface

Al principio, estaba el analógico. Una historia alternativa de los comienzos del arte computacional

Resumen

Desde finales de la década de 1960, la historiografía del arte computacional ha estado desarrollando un canon que se está ampliando progresivamente. Sin embargo, este canon revela puntos ciegos significativos, especialmente debido al éxito predominante de los ordenadores digitales, lo que hace que el arte computacional se identifique casi exclusivamente con la tecnología digital. Esta identificación pasa por alto otras clases significativas de computadoras, en particular los sistemas analógicos e híbridos, dejando sin reconocer las contribuciones, las obras de arte y las ideas de muchos pioneros del campo. En consecuencia, la historia del arte creado con ordenadores analógicos e híbridos sigue sin explorarse en gran medida tanto en la historia del arte como en la arqueología de los medios.

Este artículo pretende iluminar este capítulo relativamente oscuro de la historia presentando a las personas y proyectos que utilizaban ordenadores analógicos, aprovechando fuentes históricas previamente desconocidas. El objetivo es subrayar la importancia histórica de una tecnología el interés por la cual está actualmente experimentando un resurgimiento en el campo de la informática.

Los hallazgos revelan que antes de la llegada de los experimentos artísticos con ordenadores digitales, los ordenadores analógicos eran objeto de una exploración pionera. El funcionamiento intuitivo en tiempo real de los ordenadores analógicos fue una ventaja única, ya que presagió una relación hombre-máquina que ahora es común con la tecnología digital.

La narrativa del ordenador analógico constituye un dominio esencial para comprender la diversidad de tecnologías informáticas al inicio de la era informática. A pesar de la escasez de fuentes que documentan estos esfuerzos artísticos, este artículo sirve como un llamamiento a la acción para continuar investigando en esta área descuidada.

Palabras clave

arte computacional; ordenador analógico; ordenador híbrido; osciloscopio; plóter; interfaz hombre-máquina

Introduction

The success of the digital computer has not only affected our present but also our past. Beyond the knowledge of a handful of experts, it is largely unrecognized that in the mid-20th century, other computer technologies existed. One of them was the electronic analogue computer, a computer class of significant importance in the early days of electronic computing. With the analogue computer, the artistic experiments carried out with these computers also disappeared from our memory. In the narrative of the history of computer-related arts, they only appear in passing. This essay endeavors to refocus attention on the analogue computer and the artworks and aesthetic experiments realized with its aid – aspects of the history of computing and the arts that, except for a few instances, have largely been overlooked in the fields of media archaeology and art history (Humboldt University Berlin 2024; Zinman 2012).

1. On analogue computing

The concept of building computers with analogue electronic components took root independently across various regions during the 1930s and 1940s. Key contributions to analogue computing during this period included Helmut Hoelzer's work in Germany, George A. Philbrick's initiatives in the USA, Bell Research Laboratories' electronic fire control systems, and MIT's development of one of the earliest electronic differential analyzers. (Ulmann 2022, 41)

Electronic analogue computers, until the 1970s, stood as the fastest computing systems available for the real-time simulation of dynamic systems. Their speed made them invaluable in the aerospace sector for designing rockets and high-velocity aircraft, as well as space flight and training. They were also crucial for automotive engineering, in the chemical industry for process planning, and in electrical engineering for network analysis. (Stice & Wanson 1965, 2, 5)

A frequently noted distinction between digital and analogue computers is that analogue devices express numerical values through continuously variable physical quantities, such as electrical voltages. However, since, in the meantime, analogue computers have been built with purely digital elements (Ulmann 2023, 2), it is necessary to emphasize the fundamental difference between these classes of computers. The operational mechanisms of analogue and digital computers are inherently distinct. In general, a digital computer uses a fixed architecture to execute program instructions sequentially. In contrast, an analogue computer does not have a fixed structure,

> "in fact, a problem is solved on such a machine by changing its structure in a suitable way to generate a model, an analog of the problem. This analog is then used to analyse or simulate the problem to be solved. Thus, the structure of an analog computer that has been set up to tackle a specific problem represents the problem itself while a stored-program digital computer keeps its structure and only its controlling program changes." (Ulmann 2022, 2f.)

Analogue computers, "compute by means of setups that are analog of the problems to be solved." (Berkeley & Wainwright 1956, 75, here quoted after Ulmann 2023, 3).

Especially in the 1950s and 1960s, analogue computers offered multiple advantages compared to most of the digital mainframes of that era. These benefits were not limited to computational speed. In the early days of digital computing, those wishing to visually display the results of the computation needed to first encode the program and data onto punch cards or tapes. If this initial input was processed correctly, without interruptions from errors, the computer would then output the data onto another medium, such as a punched tape or magnetic tape. This secondary medium then directed the peripheral devices, like a plotter or a microfilm plotter, to produce the visual output. Systems that displayed the results visually in real time were rare. As such, there was no scope for an intuitive response to the visual output or the underlying model when using early digital computers. With analogue computers, though the problem still required a mathematical description and the setup of computational modules via plug connections on a patch panel, the results were immediately visible to the user. They could be observed directly on an oscilloscope or drawn by a connected plotter. Additionally, users could manipulate variables with controls like potentiometers and instantaneously observe the effects on the simulation. Alterations to the program on an analogue computer could be executed rather swiftly in a process that was far less time-consuming than the equivalent modifications on digital computers.

In addition to these characteristics, many of the era's experts emphasized another advantage of analogue computing analogue technology, the aforementioned structure of the analogy between problem and simulation:

> "Probably the chief advantage in analog computation is that the operator retains a 'feel' for his problem. The twisting of a potentiometer on the computer represents, in a very real sense, the variation of a controller setting or the changing of a coefficient in the process which is under study. […] Changes in settings of computer components thus become meaningful in terms of the real process, and the results of these changes can be interpreted immediately in the same terms. The operator can 'think as he goes,' and if interesting side-avenues open up, these can be immediately explored." (Stice & Swanson 1965, 3f)

2. On analogue devices

Since 1966, the earliest accounts of the history of computer art have cited Ben Laposky's *Oscillons*, first published in 1952 (Figure 1). However, Laposky himself clarified that computer technology was not employed in crafting these pieces. Addressing an invitation to the *tendencies 4: Computers and Visual Research* exhibition, he stated in November 1968:

"These are electronic oscillograms especially composed for abstract art or design values. They are *not* made by means of any computer programming or other computer circuitry. They are created by means of the selection and control of various electronic devices connected to especially modified oscilloscopes." (Laposky 1968)

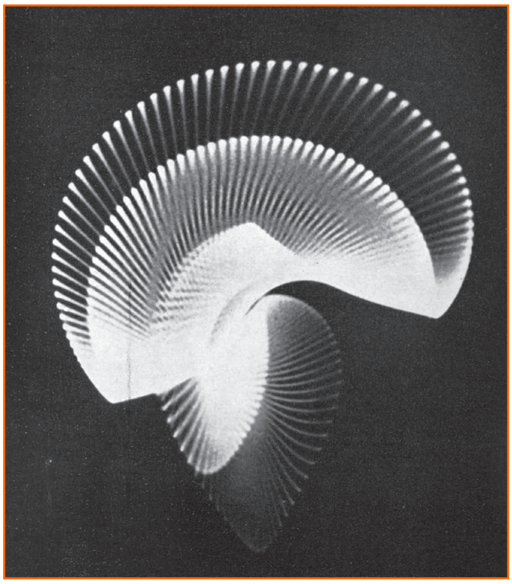


Figure 1. Ben F. Laposky's *Electronic Abstractions* (1952)
Source: *Scripta Mathematica*, (1952, September): 308-309, 308

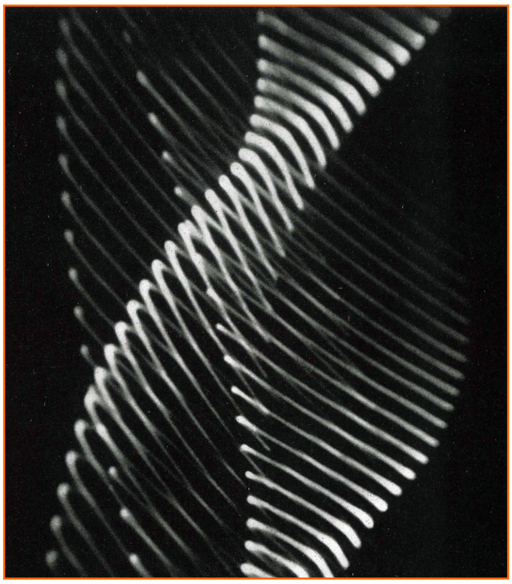


Figure 2. Herbert W. Franke's *Oszillogramm* (1956)
Source: Herbert W. Franke. "Formenspiel der Elektronen". *Foto Prisma* (6 June 1956): 310-311, 311. © Herbert W. Franke

Laposky's images were not included in the computer section of the Zagreb exhibition but in the more general "visual research" section. This section also featured Herbert W. Franke's *Oscillograms* (Figure 2), which he had been creating since 1956, inspired by Laposky. Over the years, Franke's view of the device changed. In 1968, Franke described the system as a "mixing console developed to generate and superimpose electrical alternating voltages of any time dependence" (Franke 1968) then in 1971 as an "analogue computer system" (Franke 1971).

The examples of Laposky and Franke illuminate the difficulties encountered by historians when attempting to trace how artists explored a specific technology, as it necessitates distinguishing overlapping technologies from one another. The task of tracing the path of analogue computers is particularly challenging given the great variety of analogue devices that have been used for artistic experimentation since the 1950s: was the device used for artistic experiments an electronic analogue calculating machine or an electronic signal generator linked to an oscilloscope that could be used to intuitively generate images but which was never meant to perform calculations? The distinction does hold relevance for researchers who seek to explore how electronic computers – devices at the time largely shaped by their use in the realms of military and civil engineering, science and industry – were adopted and adapted for artistic purposes. It is also of interest to researchers examining how the use of calculating machines forced their users to formalise and mathematically specify certain steps in the creative process, affecting both concepts and practises. Even though simple, custom-made analogue devices that were not originally designed for calculating procedures may seem less important from this perspective at first glance, their inclusion in the discourse on the use of analogue computers in the arts is essential, as the vagueness in communicating their technical status and a very broad definition of "computing" were part of the historical constellation. Keeping these premises in mind and considering the perspectives of the actors involved at the time, this text will focus on artworks and aesthetic experiments created with electronic analogue computers commonly used in scientific and industrial contexts for computation and simulation but conclude with an outlook on self-built analogue devices.

3. A new landscape

In 1956, a series of images generated with the assistance of an analogue computer were included in a widely distributed art publication, yet those images failed to capture significant attention from the art community. The "Oscilloscope Patterns of an Analogue Computer" were published by György Kepes in his book *The New Landscape in Art and Science*, which featured visuals assembled by the artist between 1947 and 1952 (Kepes 1956, 9). Kepes, who arrived at MIT in Cambridge in 1946 following his period at the Chicago Bauhaus, aimed to provide orientation for the inhabitants of the 20th century confronted with an environment increasingly characterized by a series of new scientific epistemologies and technologies.

> "Rapid expansion of knowledge and technical development have swept us into a world beyond our grasp; and the face of nature is alien once again. Like the forest and mountains of medieval times, our new environment harbors strange menacing beasts; invisible viruses, atoms, mesons, protons, cosmic rays, supersonic waves." (Kepes 1956, 19)

In addition to works of art history, ranging from prehistoric cave paintings to contemporary paintings, Kepes collected images created for scientific purposes. Most were photographs – from microscopy to space telescopes – but there were also x-rays and visualizations of sound and electronic voltage. The images produced by computers represented just one facet of the diverse new landscapes of technical imagery that emerged post-World War II.

Underlining the importance of visual argumentation, Kepes intentionally omitted details on how and why the scientific images were produced (Kepes 1956, 17). Only a recent serendipitous discovery in the archives of Robert Preusser, who together with Kepes co-founded the "Art for Engineers" program at MIT, has clarified the purpose of the images (Figure 3). They were the result of an aesthetic experiment and were produced no later than 1952 when Kepes finalized his collection of works. In this letter, the engineer Herbert W. Ziebolz (1903-1985) describes

> "some experiments in esthetics which were run (as a side line) [sic] in my laboratory in Chicago, when we were involved in the study of automatic submarine controls for the U.S. Navy." (Ziebolz 1965)

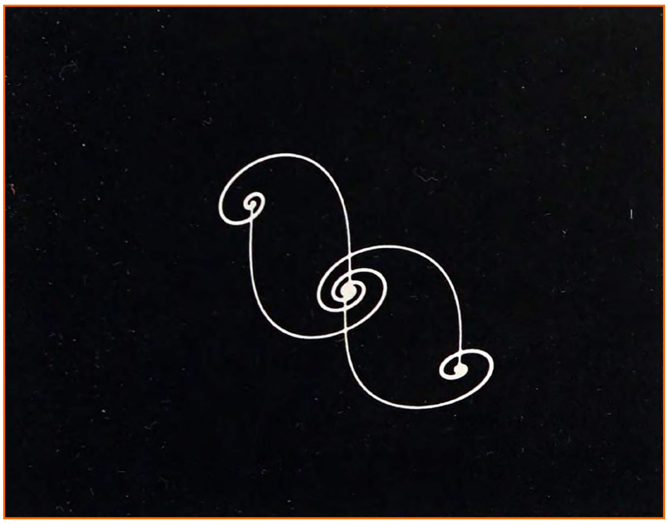


Figure 3. Herbert W. Ziebolz, *Oscilloscope Patterns of an Analogue Computer* (before 1953)
Source: Gyorgy Kepes. Ed. *The New Landscape in Art and Science*, P. Theobald, (Chicago, 1956), 180-181, 181. © Herbert W. Ziebolz

Ziebolz, who was born in Breslau, Germany, in 1903, and lived in the USA from 1927 on, made major contributions in theory and practise to the field of automatic control. During World War II he designed and developed submarine training devices for the U. S. and British navies (Slater, Iberall & Paynter 1975, 4). While working on the problem of submarine diving control, Ziebolz met George Philbrick, the American pioneer of analogue computing, who had developed a "high speed analog computer for studying submarine dynamics" (Slater, Iberall & Paynter 1975, 4). After the war, the researchers continued collaborating.

For the aesthetic experiments published by Kepes, the engineer used a Philbrick "repetitive analog computer with a repetition rate of 20 cps":

> "[We] obtained two graphs as a function of time. (a) The behaviour of the submarine i.e. depth versus time and (b) the needed control surface action as a function of time. […] By eliminating time, i.e. plotting (3-a) versus (3-b) – a so called Léauté diagram – one obtains some very beautiful spiral figurations particularly as in the case of the Philbrick computer the same trace is produced once with a plus and once with a negative sign." (Ziebolz 1965)

The work on simulations related to automatic submarine controls sparked the aesthetic interest of Ziebolz, who was also a talented amateur painter, which went beyond the mere creation of images:

> "As one has complete control of the X and Y amplification I got interested in asking various people in my Lab to so adjust this amplification ratio as to obtain the most pleasing design. […] My own choices were within an extremely narrow band of X/Y values, but I was surprised to find a great bandwidth in case of my lab members. […] Obviously this is a more sophisticated version of the "golden ratio" of the Greeks. […] However, it permits the duplication of very complex but mathematically *well defined* figures for comparative studies of esthetic preferences anywhere in the world." (Ziebolz 1965)

Ziebolz's aesthetic experiments using electronic computing technology can be considered one of the earliest known today and were prescient of developments to come. From the beginning, computers were not only used for the creation of artistic images but also for the exploration of perceptual preferences through experimental aesthetics (i.e. Noll 1966). Computers suggested these experiments insofar as image variations could be generated in a controlled manner by changing the variables within an image-generating program. It is worth noting that pseudo-random generators – which were the essential method for generating variation in digital experimental computer graphics – played hardly any role in image generation using analogue computers. Ziebolz, for instance, simply changed the variables by turning the potentiometers.

There remain unresolved issues regarding the the use of Ziebolz's images by Kepes. The reason for the omission of Ziebolz's name as a credit in Kepe's 1956 publication, in favour of the designation "Marc Campbell", is still unclear. And perhaps Kepes published an image from the Ziebolz series already in the May 1951 issue of the magazine *Arts & Architecture* (Kepes 1951, 22), and maybe the pictures were also on display at the exhibition *The New Landscape* in MIT's Hayden Gallery in the spring of 1951. To verify this, it would be necessary to examine the original photographs, yet currently, their location remains unknown.

4. Germany

In Europe, the earliest known example of a computer-generated drawing being published in the art context dates back to 1962. The German artist Kurd Alsleben (1928, Königsberg (Chojna) - 2019, Hamburg) published four "drawings of an analogue computer" (Alsleben 1962, 51, 52) (Figure 4) in his book Aesthetische Redundanz. Abhandlungen über die artistischen Mittel der bildenden Kunst (Aesthetic redundancy. Treatises on the artistic means of the visual arts). Alsleben, who graduated from the Karlsruhe Art Academy and began working in 1956 for a company that designed open-plan offices, had explored the potential application of cybernetics and information theory to art and design for many years. The pictures were created in 1960 during a visit to his childhood friend, Cord Passow, who worked as a physicist at DESY (Deutsches Elektronen-Synchrotron) in Hamburg and had access to a PACE 231R, an analogue computer manufactured by Electronic Associates Inc, which was one of the most extensively utilized analogue computer systemsworldwide at that time.

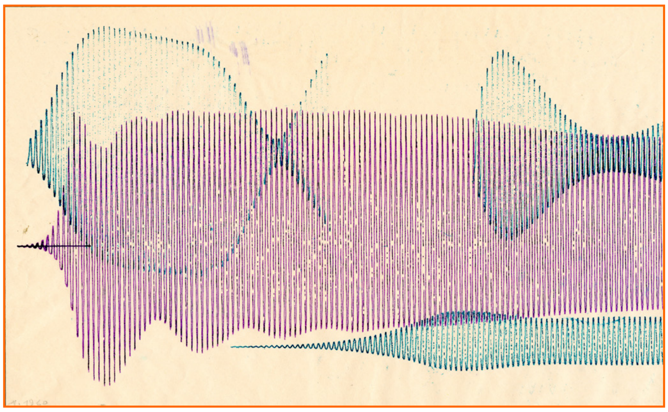


Figure 4. Kurd Alsleben, Cord Passow, *1-1960* (1960)
Source: Collection ZKM | Center for Art and Media Karlsruhe. © Kurd Alsleben, Cord Passow

Like Kepes, Alsleben foresaw the emergence of new visual landscapes and envisioned an art in which "the object of representation [...] could be a Madonna or a differential equation" (Alsleben 1962, 44):

> "Image realizations by electronic computing systems will not be limited to using the graphic appeal of an automatic recorder and its statistical disturbances [...] or to designing envelopes of curves [...], but will presumably give meaning back to the subject of the image – now as a differential equation. The spectator will learn to observe curves and their parameter changes." (Alsleben 1962, 44)

The PACE 231R analogue computer was not only a source of inspiration for Alsleben and Passow. Inge Borchardt (1934, Stettin (Szczecin)-), who had been working as a programmer at DESY since 1961, also used this computer system to produce a series of drawings in 1966 (Figure 5). These works were exhibited at the Laeiszhalle in Hamburg on the occasion of a chamber music concert on April 6. (Ingeborg Borchardt, e-mail to author, 15 March 2007) With a background as a physical-technical assistant and having studied physics up to the intermediate diploma, Borchardt was one of a handful of female programmers whose aesthetic experiments were publicly exhibited in the 1960s.

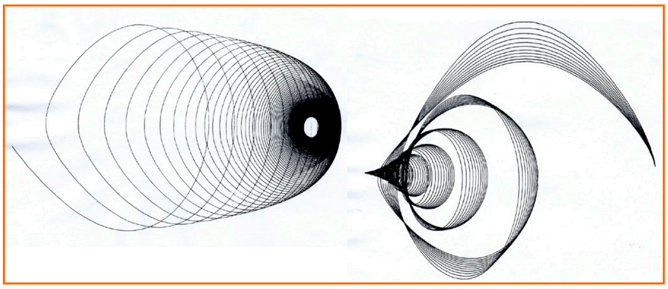


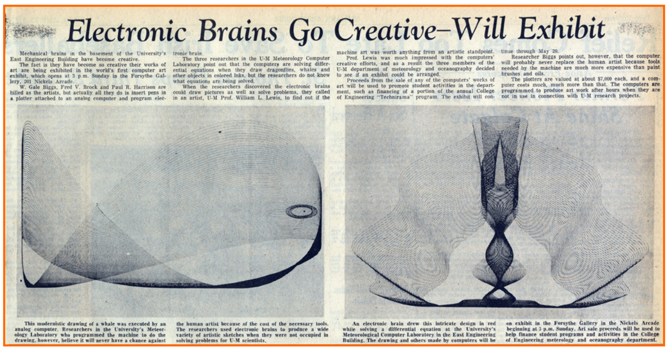
Figure 5. Inge Borchardt, *untitled* (1966)
Source: © Inge Borchardt

Due to its widespread distribution, the EAI's PACE series keeps reappearing in the early history of the use of analogue computing in the arts. The mathematician Roland Fuchshuber (*Würzburg, 1932), also used a PACE analogue computer for his aesthetic experiments. By his own account, he started to create drawings in 1960 while serving as a EURATOM member in the CETIS group (Centre de traitement de l'information scientifique) in Brussels and Ispra, Italy (Fuchshuber & Pauli 1967, 1). Yet, it was not until 1966 that he presented these works to the public. The drawings he displayed in the late 1960s received critical acclaim for their direct reference to reality, particularly in their depiction of non-linear biological or physical processes, such as a heart attack (Pfeiffer 1970, 1900).

5. USA

In 1965 and 1966, a decade after György Kepes published Herbert Ziebold's aesthetic experiments in *The New Landscape*, two exhibitions showcasing images generated by analogue computers caught the attention of the broader US public for the first time.

On 26 April 1965, an exhibition that was announced as "the world's first computer art exhibit." (anonymous 1965) opened at the Forsythe Gallery in Ann Arbor – it appears that the organizers were not aware of the *Computer-Generated Pictures. A. Michael Noll, Bela Julesz* exhibition at the Howard Wise Gallery, which debuted on April 4, 1965, nor of the exhibition at the San Jose University Spartan Book Store, featuring experiments by Joan Shogren, Ralph James Fessenden, Jim Larsen and Marvin Coon, which opened on 8 May 1963. The Forsythe Gallery displayed not only plotter drawings with abstract forms but also many figurative ones, such as a whale, a dragonfly and a butterfly. They were created by three graduate students at the University of Michigan's Meteorology Computer Laboratory: W. Gale Biggs (1935-2023), Fred V. Brock (1932-2020) and Paul R. Harrison. A newspaper article titled "Electronic Brains Go Creative – Will Exhibit" (anonymous 1965) – Figure 6 – mentioned that the images were created on an analogue computer to solve differential equations, but when Biggs was interviewed 40 years later, he stated that they actually used a "combined (hybrid) analog/digital computer" developed by Brock that united the strengths of both systems (Biggs, e-mail to author, 9 October 2006). Typically, the digital component of a hybrid computer acts as a controller, facilitating logical and numerical operations. According to Biggs, the idea of creating non-scientific images came up during a meteorological study of the Indian Ocean, where they needed to visualize data on air and water temperatures, as well as winds and turbulence (Biggs, e-mail to author, 13 February 2007). After the Ann Arbor exhibition, the works and their creators became obscure. They were absent from the series of exhibitions in Europe and the US that in 1968 started to map out a history of computer art that today's historiography still largely follows.



Electronic Brains Go Creative–Will Exhibit

Mechanical brains in the basement of the University's East Engineering Building have become creative.

The fact is they have become so creative their works of art are being exhibited in the world's first computer art exhibit, which opens at 3 p.m. Sunday in the Forsythe Gallery, 201 Nickels Arcade.

W. Gale Biggs, Fred V. Brock and Paul R. Harrison are billed as the artists, but actually all they do is insert pens in a plotter attached to an analog computer and program electronic brain.

The three researchers in the U-M Meteorology Computer Laboratory point out that the computers are solving differential equations when they draw dragonflies, whales and other objects in colored inks, but the researchers do not know what equations are being solved.

When the researchers discovered the electronic brains could draw pictures as well as solve problems, they called in an artist, U-M Prof. William L. Lewis, to find out if the machine art was worth anything from an artistic standpoint.

Prof. Lewis was much impressed with the computers' creative efforts, and as a result the three members of the U-M department of meteorology and oceanography decided to see if an exhibit could be arranged.

Proceeds from the sale of any of the computers' works of art will be used to promote student activities in the department, such as financing of a portion of the annual College of Engineering "Technirama" program. The exhibit will continue through May 20.

Researcher Biggs points out, however, that the computer will probably never replace the human artist because tools needed by the machine are much more expensive than paint brushes and oils.

The plotters are valued at about $7,000 each, and a computer costs much, much more than that. The computers are programmed to produce art work after hours when they are not in use in connection with U-M research projects.

This modernistic drawing of a whale was executed by an analog computer. Researchers in the University's Meteorology Laboratory who programmed the machine to do the drawing, however, believe it will never have a chance against the human artist because of the cost of the necessary tools. The researchers used electronic brains to produce a wide variety of artistic sketches when they were not occupied in solving problems for U-M scientists.

An electronic brain drew this intricate design in red while solving a differential equation at the University's Meteorological Computer Laboratory in the East Engineering Building. The drawing and others made by computers will be on exhibit in the Forsythe Gallery in the Nickels Arcade beginning at 3 p.m. Sunday. Art sale proceeds will be used to help finance student programs and activities in the College of Engineering meterology and oceanography department.

Figure 6. "Electronic Brains Go Creative – Will Exhibit", *The Ann Arbor News*, (23 April 1965)

Maughan S. Mason's show at the Salt Lake Art Center was introduced by its curator, James L. Haseltine, as "the country's first one-man show of computer-generated drawings" (Haseltine 1966, 15). This statement was not entirely accurate, as in fact, Mason had previously presented a solo show from 30 November to 1 December 1965, at the Fall Joint Computer Conference in Las Vegas, Nevada (Archives of Intermountain Art 1966). The drawings he displayed in Salt Lake City were all "based upon various combinations of sinusoids" (Mason 1966) – Figure 7. Experimenting with different colors, Mason created large-scale drawings, some up to 102 x 76 cm, featuring an array of forms including Lissajous figures, flags with moiré patterns, concentric spirals and other shapes that viewers found reminiscent of Op Art (Haseltine 1966, 16). Under the title "A Computer is His Paint Brush" *The National Observer* wrote:

> "Plotting missiles and rockets with a computer's aid is his workaday life, but Maughan S. Mason finds that a computer can have an artistic use too. He programs wave forms and patterns into a computer, which then turns out the mathematically precise results on a plotting board." (anonymous 1966)

Mason (1931, Ogden, Utah - 2003, Saratoga, California), who had a degree in physics, had actually been involved in missile and rocket simulations since the start of his career. Beginning in 1953, he worked at White Sands Missile Range in New Mexico until 1959, when he became head of the analogue simulation facility at Thiokol Chemical Corporation near Brigham City, Utah (anonymous 1964, Mason 1966). This site, where Mason created the drawings, had specialized in the development of rocket engines.

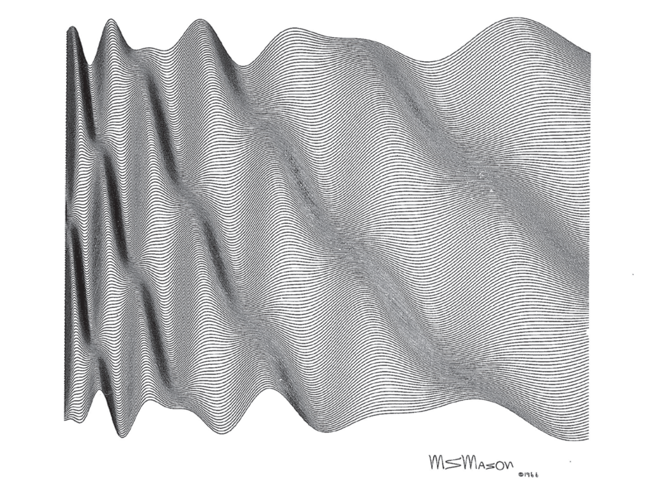


Figure 7. Maughan S. Mason, *Sensuality* (1966)
Source: © Maughan S. Mason, Utah Museum of Contemporary Art Archives

The show's curator, Haseltine, believed that computers would gradually find their place in the realm of art and, over time, transform it – here his thoughts seemed to echo Kurd Alsleben's statement – also on the level of representation:

> "we may soon be hearing from the classicists – the purists, constructivists, and hard-edge and op artists – much talk of decaying exponentials, sinusoid amplitude, plotting axes, diode gain changes, Gaussian quadratics, and, "free-running integrators," (Haseltine 1966, 18)

Kepes, Alsleben, Hazeltine and others were wrong. When it came to physics, mathematics and the natural sciences, the public and art critics remained largely illiterate.

6. Eastern Europe

In the 1960s, Eastern European countries also saw the creation of images on analogue computers. For instance, starting in 1966, the Czech engineer Lubomir Sochor generated images using the NADAC 1000 – a system produced by the French company Société d'Electronique et d'Automatisme (SEA) – at the computer center of the Central Military Hospital in Prague (Sochor 1967; 1968: Chrobák 2018, 26). These images were displayed in the *computer graphic* exhibition at the Dům umění města in Brno that opened in February 1968. Another case involved the computer center at the Institute of Nuclear Sciences Boris Kidrič in Vinča, Croatia, which presented four abstract drawings in the *tendencies 4. computers and visual research* exhibition in Zagreb starting May 1969 (Franke 1968).

7. The other analog

The origins of the projects given in this overview reflect the diverse military and civilian applications of analogue computers at the time. As with most computer-generated drawings produced at technical or scientific computing centers, it was mere chance that determined whether these drawings would end up just hanging in the institute's or company's cafeteria or would capture the attention of the art world, making their mark in history. What all these projects have in common is that the devices were used contrary to their intended purpose. The small historical overview shows that the primal scene of new media as defined by Kittler – the "misuse of army equipment" – (Kittler 1986, 149, 169, 196) turns out to be one of many appearances of the phenomenon that humans tend to playfully detach tools from the problems they were created to solve.

Artists typically lacked access to large-scale computer systems, whether digital or analog. Instead, they created or used analogue and hybrid devices that shared characteristics with electronic analogue computer technology and were sometimes referred to as "analogue computers", either by the artists or by external observers. A look at these projects sheds light on the artists' expectations of the electronic tools that emerged after the Second World War.

Most of the custom-built devices consisted of a signal generator, a mixer and an oscilloscope, but there were also examples of a greater technical complexity. What they had in common was the use of an oscilloscope and the possibility of intuitive interaction with the device. With the possibility of intuitive reaction to the visible simulation, analogue computers were close to the cybernetic ideas of feedback and the control loop, in contrast to digital computers, which at that time were more like programmable painting machines. (The mechanical devices that Desmond Paul Henry and James Whitney created from components of mechanical analogue computers used for bomb- and gun-aiming, are mentioned as they periodically surface in the history of computer art but are not part of this argument.)

Many of the works generated with electronic analogue or hybrid devices have been preserved, for example: photographs and prints by Ben Laposky, Herbert W. Franke, the ars intermedia group (Otto Beckmann, Oskar Beckmann and Alfred Grassl) and the films by Norman MacLaren, Mary Ellen Bute and Hy Hirsh. One of the few testimonials describing the fascination of working with electronic analogue technologies was written by Franke:

> "The pleasant thing about working with the oscilloscope is that you can set the arbitrarily selectable values on control buttons. So you sit in a darkened room, your hands on the control panel, and observe the result directly on the illuminated screen. It is a feeling similar to that experienced by an improvising musician. You see the most adventurous shapes emerge and dissolve, wander and circle, contract and dissolve. I sat in front of the magic screen for hours and watched the bright green glowing lines [...]." (Herbert W. Franke 1957, 28)

The magic of the moving electron beam, which captivated artists, ties into a broader narrative – the history of our fascination with electricity as an invisible force that becomes visible only through devices like the oscilloscope (Zielinski 2002). As Leo Graetz noted in *Die Elektrizität und ihre Anwendungen* in 1883, humans lack an "electrical sense" (Graetz 1922, XIV; Zielinski 2005, 95). Both the custom-built devices and the electronic analogue rendered electrical signals visible, creating fluid forms whose mathematical elegance seemed to reveal the underlying principles of the universe. These shapes greatly contrasted with early digital computers, which were characterized by straight lines and rectangular shapes, as they were struggling to render curved and circular forms that needed to be broken down into tiny, incremental steps.

For some artists, analogue computer technology represented a vision of what computers as such could ultimately offer to artistic work in terms of visual possibilities and interaction. Particularly noteworthy is the engineer Oskar Beckmann (1942, Vienna - 2022, St. Pölten), for example, who designed a hybrid computer called the Ateliercomputer a.i./70 for his father, the artist Otto Beckmann (1908, Vladivostok – 1997, Vienna), which was operational by 1970 (Figure 8). The ambition behind creating this device extended beyond mere image production. The "studio computer," merging digital state processors with analogue components, was part of a bigger project termed "experimental computer science" (Beckmann 1971, 6). This endeavor aimed to equip artists with an ideal tool, independent of large corporations, and to foster new creative models through the exploration of intuitive human-machine interaction.

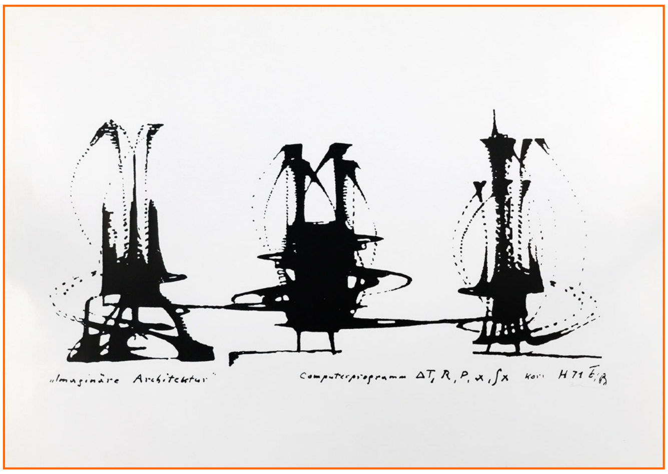


Figure 8. Otto Beckmann and Oskar Beckmann, *Imaginäre Architektur* (1971)
Source: Collection ZKM | Center for Art and Media Karlsruhe. © Otto Beckmann, Oskar Beckmann

Conclusion

This study set out to explore the pioneering aesthetic experiments conducted with analogue computers, incorporating previously unexamined sources to enrich the discourse. The research revealed that these artistic endeavors began as early as the 1950s, predating digital computer art. The text underscores the necessity for a technical distinction among the various classes of computing devices, highlighting the diversity and unique operational characteristics of analogue and hybrid computers. Unlike their digital counterparts, which functioned more as programmable painting machines, analogue computers offered a more intuitive means for simulating processes, aligning closely with the cybernetic ideals of feedback and control loops. The implications of this research are twofold. Firstly, it broadens the scope of "computer art history" by including the contributions of analogue computing, thus challenging the prevailing narrative that has predominantly focused on digital computers. Secondly, it underscores the significance of recognizing analogue and hybrid computers as integral components of the broader computing history, each contributing uniquely to the development of art and technology. Looking forward, the discovery of additional documents could further illuminate this chapter of art history. While direct interviews with contemporaries may no longer be feasible, a detailed technical analysis of existing devices remains a crucial avenue for future research.

References

Alsleben, Kurt. *Aesthetische Redundanz. Abhandlungen über die artistischen Mittel der bildenden Kunst*. Quickborn: Schnelle, 1962.

Anonymous. "A Computer is His Paint Brush". *The National Observer*, (02 May 1966).

Anonymous. "Electronic Brains Go Creative – Will Exhibit". *The Ann Arbor News*, (23 April 1965).

Anonymous. "Presenting ... Maughan Mason". *Simulation*, vol. 5, no. 2 (May 1964): 2.

Archives of Intermountain Art – Salt Lake Art Center. Biographical Information [Maughan S. Mason]. Utah Museum of Contemporary Art Archives, 1966.

Beckmann, Otto and Oskar Beckmann. "ars intermedia. Experimentalarbeitsgruppe Wien und St. Pölten". *ars intermedia Werkbeiträge zur Computerkunst*. Vienna: Datenzentrum der Zentralsparkasse Wien, 1971.

Berkeley, Edmund Callis and Lawrence Wainwright. *Computers – their Operation and Applications*. New York: Reinhold Publishing Corporation, 1956.

Chrobák, Ondřej (ed.). *1968: computer.art*. Brno: Moravská Galerie, 2018.

Fuchshuber, Roland and Franz Pauli (eds.). *Studien zum Man-Machine-Interface. Fuchshuber / Pauli*. Cologne: self-published, 1967.

Franke, Herbert W. *Kunst und Konstruktion*. Munich: Bruckmann, 1957.

Franke, Herbert W. 1968. "untitled". *tendencije 4*. Zagreb: Galerija suvremene umjetnosti, 1970.

Franke, Herbert W. "Analog- und Digitalgrafiken". *Werkstatt-Edition Kroll. Computergrafik*. Munich: Galerie Franzius, 1971.

Graetz, Leo. *Die Elektrizität und ihre Anwendungen*. Stuttgart: J. Engelhorn, 1922 [1883].

Galerija suvremene umjetnosti (ed.). *tendencije 4*. Zagreb: Galerija suvremene umjetnosti, 1970.

Haseltine, James L. "The Computer and the Artist". *Utah Architect* (1966, Autumn): 15-18.

Holst, Per A. "George A. Philbrick and Polyphemus – The First Electronic Training Simulator". *Annals of the History of Computing*, vol. 4, no. 2 (1982, April): 143-156. DOI: https://doi.org/10.1109/MAHC.1982.10021

Humboldt University Berlin. "Think Analogue! Archäologie, Präsenz und Künftigkeiten des Analogcomputers". (n.d.). https://web.archive.org/web/20131015074800/http://think-analogue.hu-berlin.de. [Accessed: 27 February 2024].

Kepes, György. "The New Landscape". *Arts & Architecture*, vol. 68, no. 5 (1951, May): 21-24.

Kepes, György (ed.). *The New Landscape in Art and Science*. Chicago: P. Theobald, 1956.

Kittler, Friedrich A. *Grammophon, Film, Typewriter*. Berlin: Brinkmann & Bose, 1986. https://doi.org/10.2307/778332

Muche, Georg. *Die Kunst stirbt nicht an der Technik*. Schüchtern: Ludwig Steinfeld, 1954.

Laposky, Ben F. "Letter to Boris Kelemen". Zagreb: Archives MSU, 22 November 1968.

Mason, Maughan S. "Letter to John McLeod." Utah: Museum of Contemporary Art Archives, 11 February 1966.

Noll, A. Michael. "Human or Machine: A Subjective Comparison of Piet Mondrien's 'Composition with Lines' (1917) and a Computer-Generated Picture". *The Psychological Record*, vol. 16, (1966): 1-10. DOI: https://doi.org/10.1007/BF03393635

Pfeiffer, Günter. "Kunst und Computer. Kybernetik – Informationsästhetik – Computer-Art". *Magazin Kunst. Das aktuelle Kunstmagazin*, 10th year, no. 39, (1970, 3rd quarter): 1883-1901.

Slater, L. E., A. S. Iberall and H. M. Paynter. "On Herbert W. Ziebolz". *Journal of Dynamic Systems, Measurement, and Control* (1975, March): 4-5. DOI: https://doi.org/10.1115/1.3426872

Sochor, Lubomir. "Letter to Jiri Valoch", (7 November 1967).

Stice, James E. and Bernet S. Wanson. *Electronic Analog Computer Primer*. New York, London, Toronto: Blaisdel Publishing, 1965.

Ulman, Bernd. *Analog Computing*. Oldenburg: De Gruyter, 2022.

Ziebolz, Herbert. "Letter to Robert O. Preusser", (16 December 1965). Robert O. Preusser Papers, MC-0219, box 5. Cambridge, Massachusetts: Massachusetts Institute of Technology, Department of Distinctive Collections.

Zielinski, Siegfried. *Archäologie der Medien. Zur Tiefenzeit des technischen Hörens und Sehens*. Reinbek/Hamburg: Rowohlt, 2002.

Zielinski, Siegfried. "Show and Hide. Projection As a Media Strategy Located between Proof of Truth and Illusionising". In: Siegfried Zielinski and Silvia Wagnermaier (eds.). *Variantology 1. On Deep Time Relations of Arts, Sciences and Technologies*, (Köln: Buchhandlung Walther König, 2005), 81-102.

Zinman, Gregory. "Analog Circuit Palettes, Cathode Ray Canvases: Digital's Analog, Experimental Past". *Film History: An International Journal*, vol. 24, no. 2, (2012): 135-157. DOI: https://doi.org/10.2979/filmhistory.24.2.135

CV

Margit Rosen
ZKM | Center for Art and Media Karlsruhe
margitrosen@gmx.de

The art historian has been Head of the department Wissen (Collection, Archives & Research) at the ZKM | Center for Art and Media in Karlsruhe since 2016. She has taught at various universities, including the University for Art and Design Karlsruhe (HfG), the Danube University Krems, the Münster Art Academy, the Central Academy of Fine Arts (CAFA) in Beijing, and the Università degli Studi di Milano. Her curatorial work, research and writing are focused on 20th and 21st century art, with a particular emphasis on the history of the relationship between art and new technologies. Among her publications is *A little-known story about a movement, a magazine, and the computer's arrival in art: New Tendencies and Bit International, 1961-1973* (Cambridge, Massachusetts: The MIT Press, 2011).